A New Paradigm for Organic Chemistry in the Nebula: Protostars as Chemical Factories

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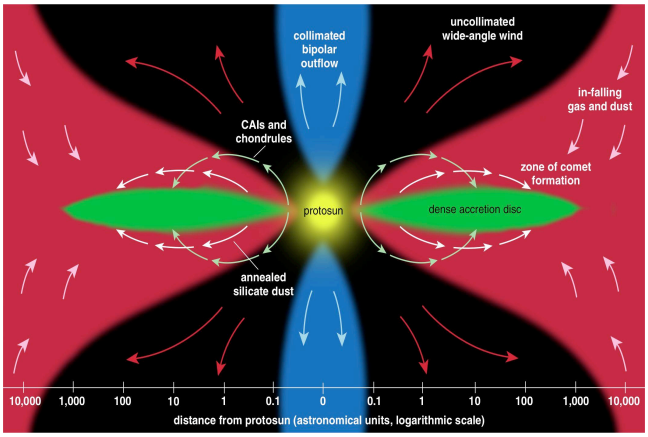
Protostellar nebulae are oxygen rich, yet a significant quantity of organic matter is still evident in meteorites and in comets when one might predict that such materials should have reacted with the silicate dust to form large amounts of CO. We know that nearly all meteoritic material was processed through a series of high temperature events, producing Calcium Aluminum Inclusions (CAIs), chondrules, crystalline silicate dust and amorphous condensates. By analogy a similar proportion of the carbonaceous grains should also have experienced these same conditions, yet macromolecular carbonaceous coatings exist on grains in meteorite matrices and volatile organic molecules are observed in reasonable abundance in comets. We propose that surface mediated reactions on silicate dust grains could have played a major role in the production of both volatile and macromolecular carbonaceous materials in the nebular environment. This is based on the recognition that both inward as well as outward circulation must occur in protostellar nebulae in order to explain the presence of crystalline silicate grains, and on recent experiments in our lab that demonstrate the resilience of surface mediated organic synthesis. We will discuss the basic model of nebular circulation as it related to the production of crystalline mineral grains found in comets. A summary of this general circulation model is shown on the right, below.



Our recent experiments have demonstrated that almost any free surface will act to catalyze the Fischer-Tropsch-Type conversion of CO and molecular hydrogen to complex hydrocarbons. In addition, we have now discovered that one of the products of these reactions is a macromolecular carbon coating on the grain surface that itself acts as a catalyst to promote the formation of hydrocarbons containing nitrogen if the reaction occurs in the presence of N_2, H_2 and CO. Far from acting as a poison, these coatings can greatly enhance the reactivity of some grain species such as amorphous magnesium silicate or silica particles. The net result of this process should be a relatively uniform composition for the macromolecular carbonaceous materials deposited on meteoritic grains and a significant increase in the quantity of organic materials that may have been produced and then circulated throughout protostellar nebula compared to previous models.